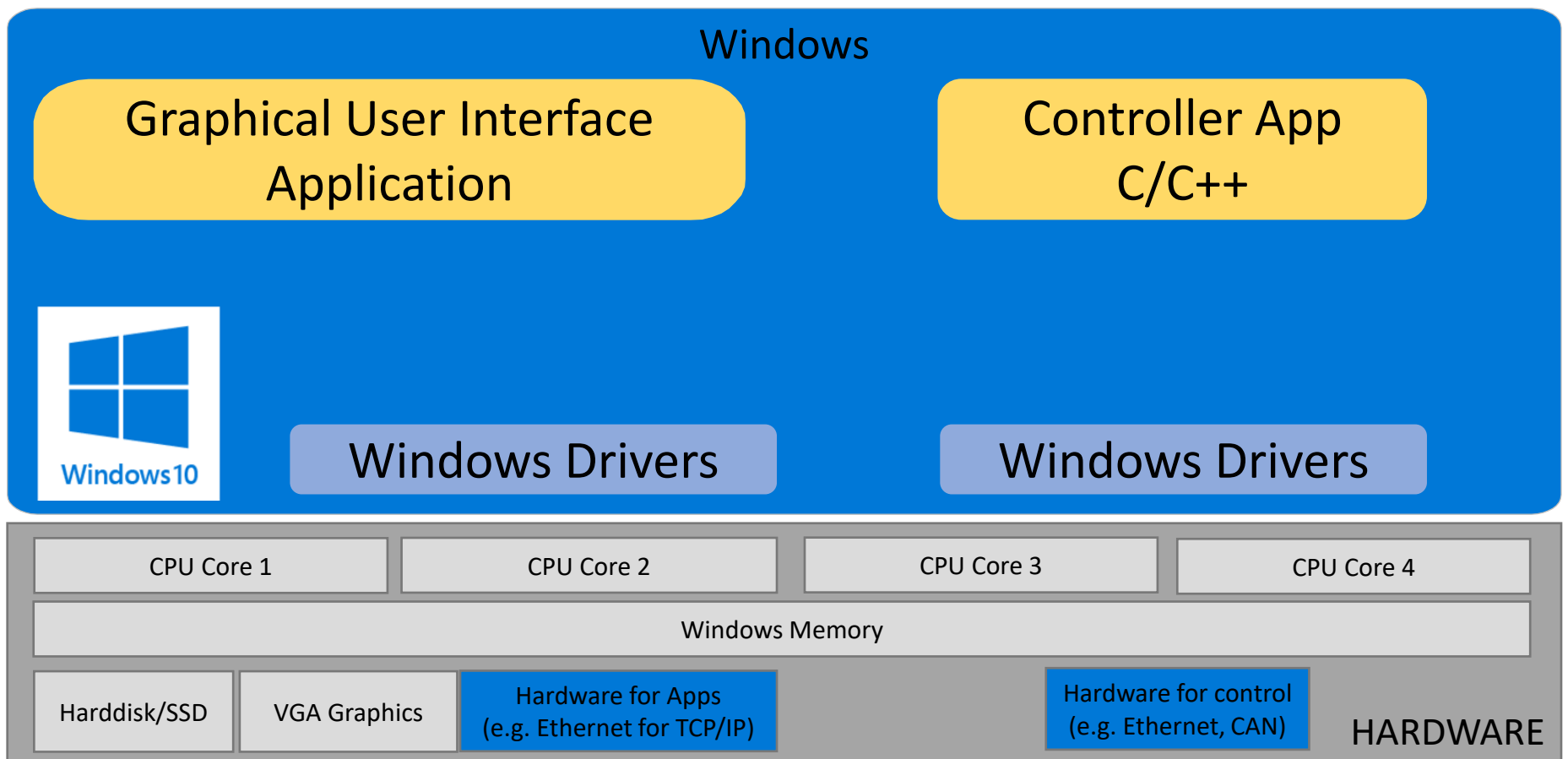




Windows Real-time Extension

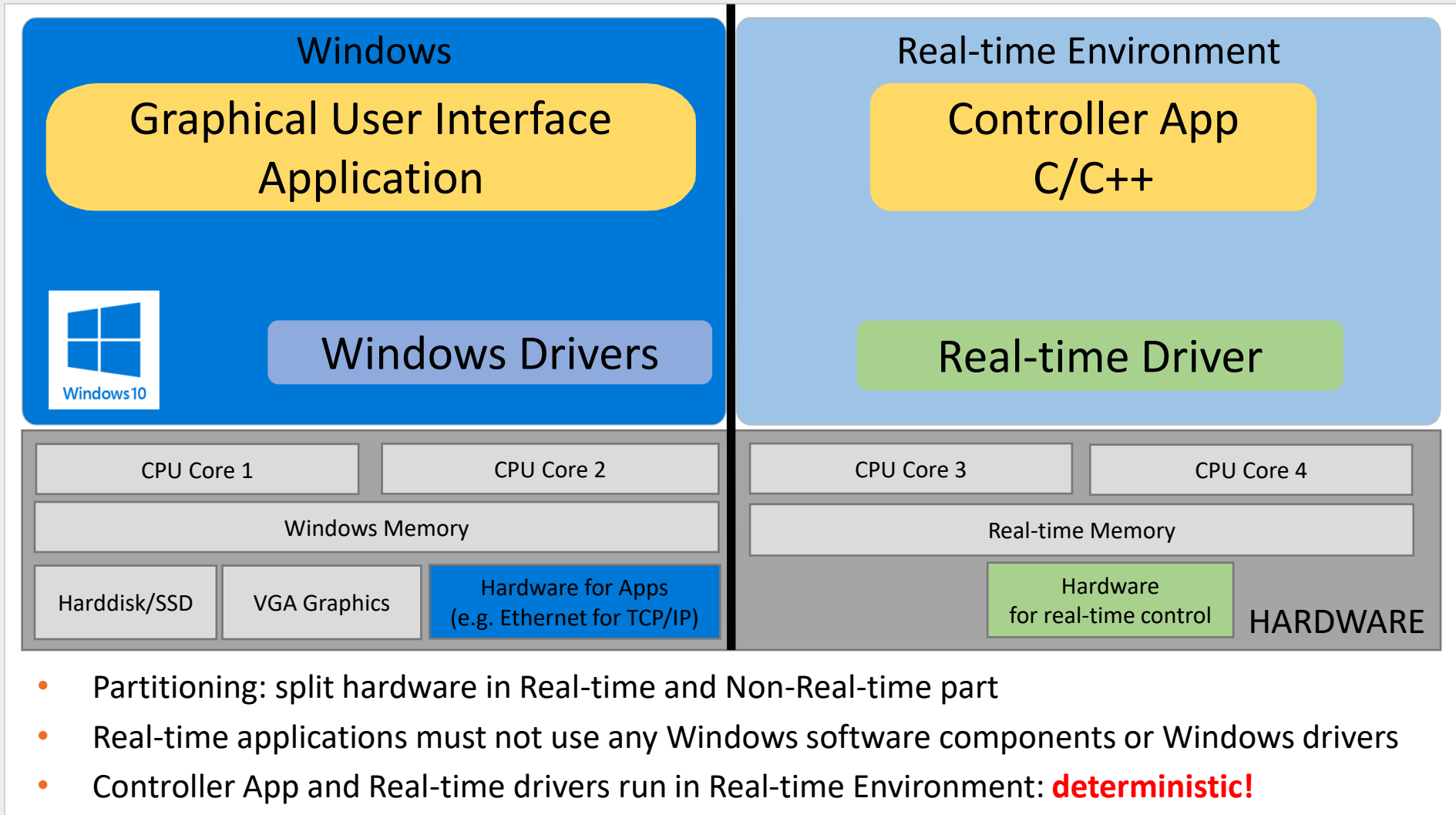
August 2020

Design without Real-time Environment



- Controller App and Drivers run on Windows: **no determinism!**

Design with Real-time Environment

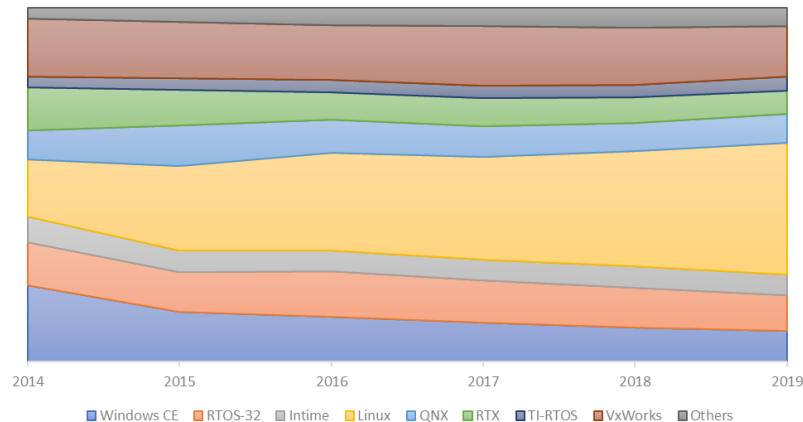




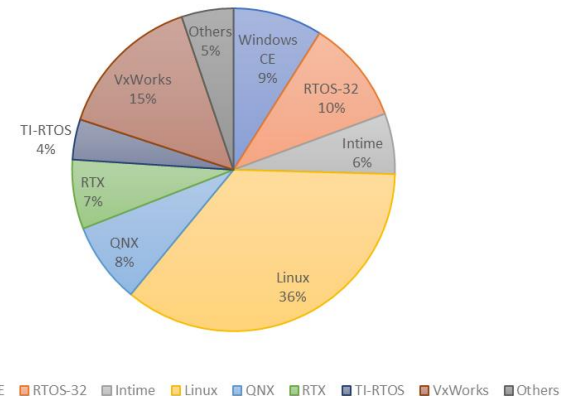
Real-time Linux

- acontis approach
 - Hypervisor based solution: better isolation, more robust
 - no proprietary real-time environment
- The most popular real-time OS: RT-Linux
 - Used by most customers all over the world

acontis EtherCAT Master Real-time OS Adoption over Time



acontis EtherCAT Master Real-time OS Adoption

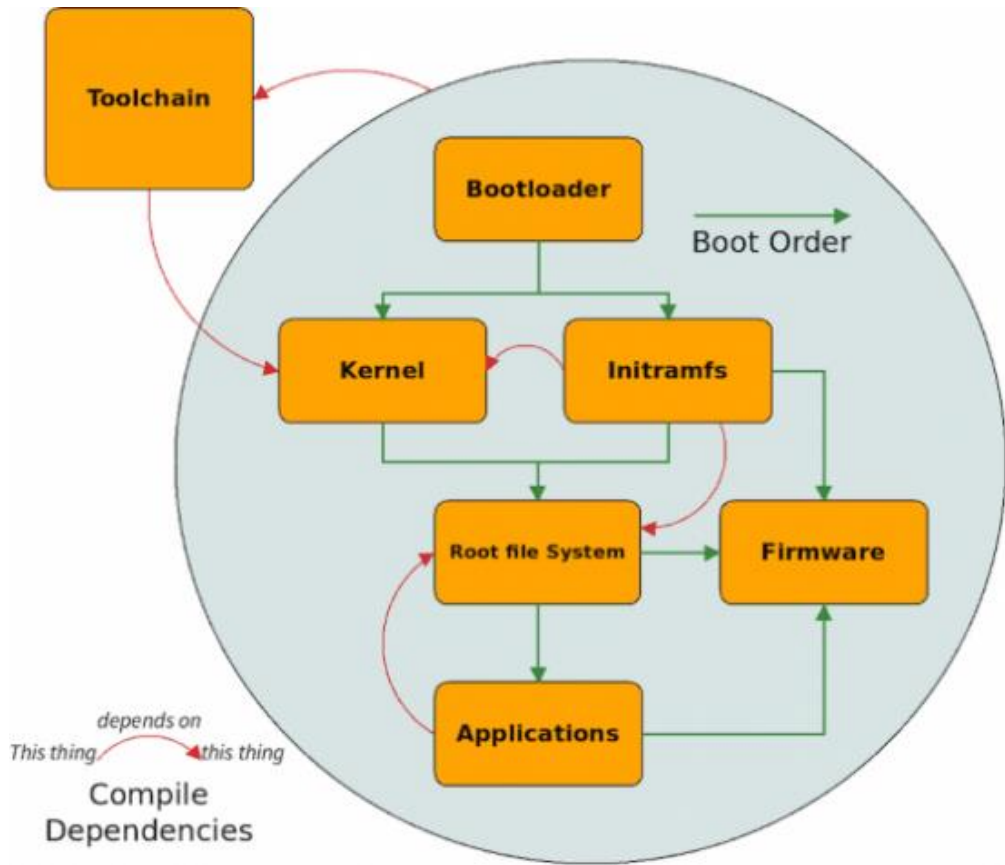


- RT-Linux today: the most powerful real-time OS available (API richness, OS capabilities, ...)
- Thousands of drivers, hundreds of third-party products available

- RT Preempt Patch
 - Adds hard real-time to Linux, proven in thousands of industrial applications
 - LxWin: ready to use headless real-time image included
 - Customer does not need to be a Linux expert
 - Real-time capabilities verified by acontis
 - Customer can concentrate on the application part
- Posix support
 - Standard API for real-time and multitasking programming (e.g. threads, semaphores, ...)
- Win32 support
 - acontis provides wrappers and code snippets for porting purposes
- Scalable Solutions can be built
 - Level 1: Embedded Controller without GUI: use native, embedded Linux
 - Level 2: Embedded Controller with GUI: use native Linux with GUI (e.g. Qt)
 - Level 3: High End Controller with powerful Windows GUI: use LxWin

- Hard real-time performance (extremely short latencies).
- 64 Bit and 32 Bit support
- Symmetric multiprocessing (utilize multiple cores)
- Powerful OS
 - Separate applications from Kernel
 - Powerful communication means
 - Posix compliant
 - Great development tools

Linux Architecture



- **Bootloader**
 - Most popular in most distributions: grub
 - LxWin: Uploader tool
- **Kernel**
 - Linux Kernel + essential built-in drivers
 - LxWin: Created using Yocto
 - LxWin: adjusted to support acontis Hypervisor
 - Goal: small kernel for typical customer applications (e.g. no drivers for hard disk etc.)
- **Initramfs**
 - RAM filesystem with additional driver modules, tools and some applications (e.g. busybox with shell)
 - LxWin: Created using Yocto
 - Goal: as small as possible
- **Root file system**
 - Typically located on a hard disk or SSD
 - Contains all driver modules, applications etc.
 - LxWin: identical to the Initramfs
- **Firmware**
 - For specific hardware to update internal firmware
 - LxWin: currently not used

- **Applications**
 - typically stored in the root filesystem (on the hard disk)
 - LxWin: mounted into Linux at /mnt/rfiles or part of the initramfs
- **Toolchain**
 - Windows development host: Provided by acontis (gnu toolchain). Created using crosstool-NG.
 - Linux development host: Standard GNU toolchain can be used.
 - Remote Debugging using gdb on the debug host and the gdbserver running in the LxWin image. Connection using ssh over TCP/IP (virtual network)

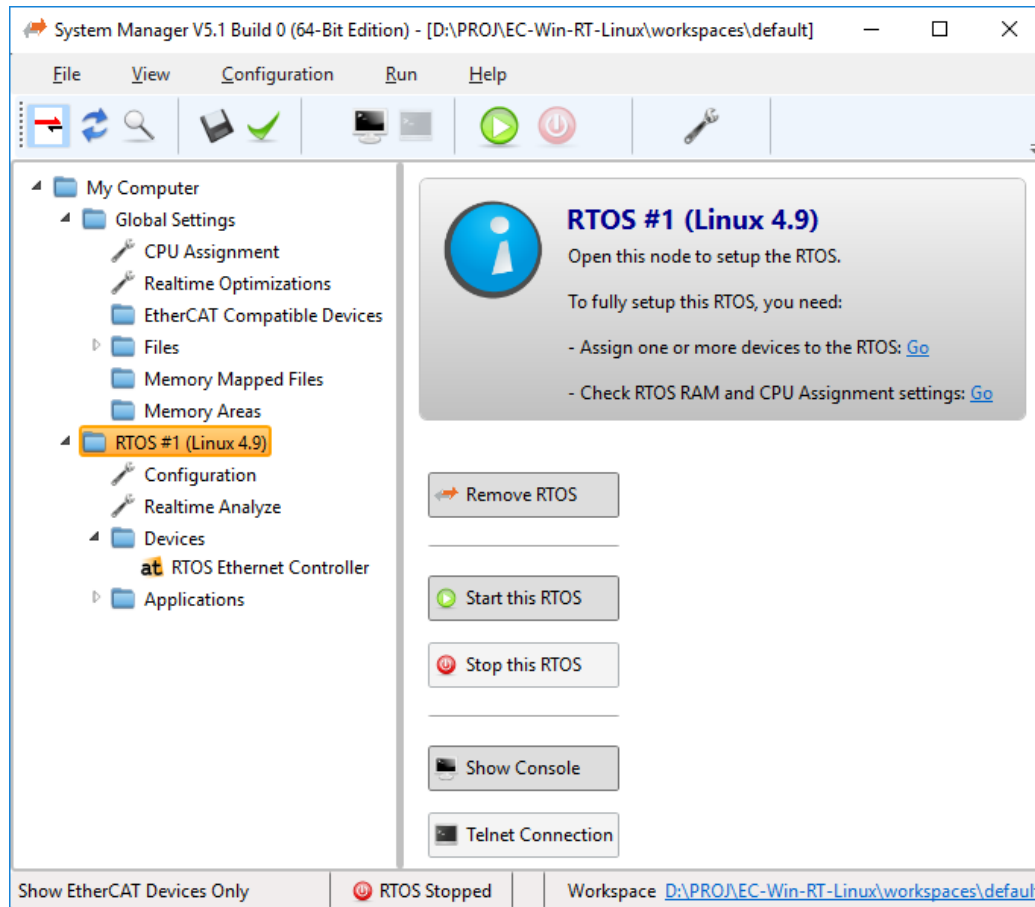


System Manager Tool

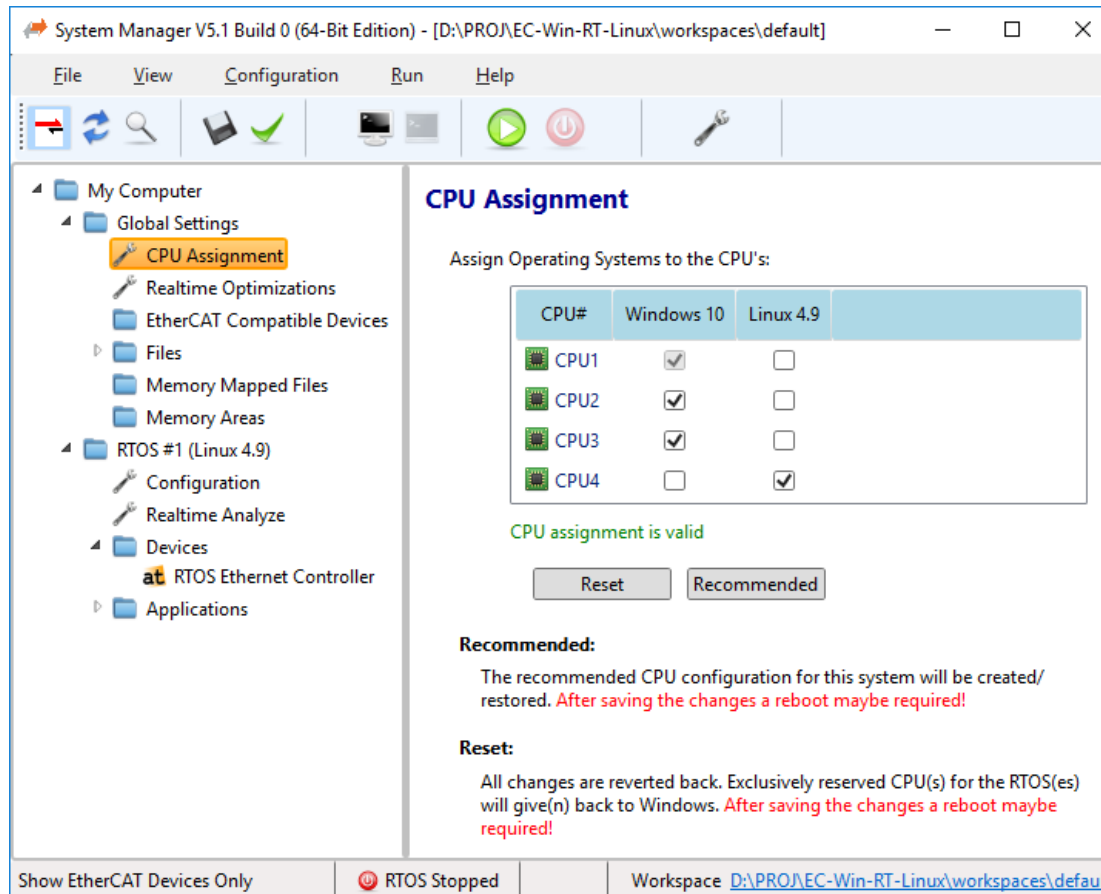
Configuration and Development Management Console

System Manager Tool: Management Console

GUI for configuration and runtime management



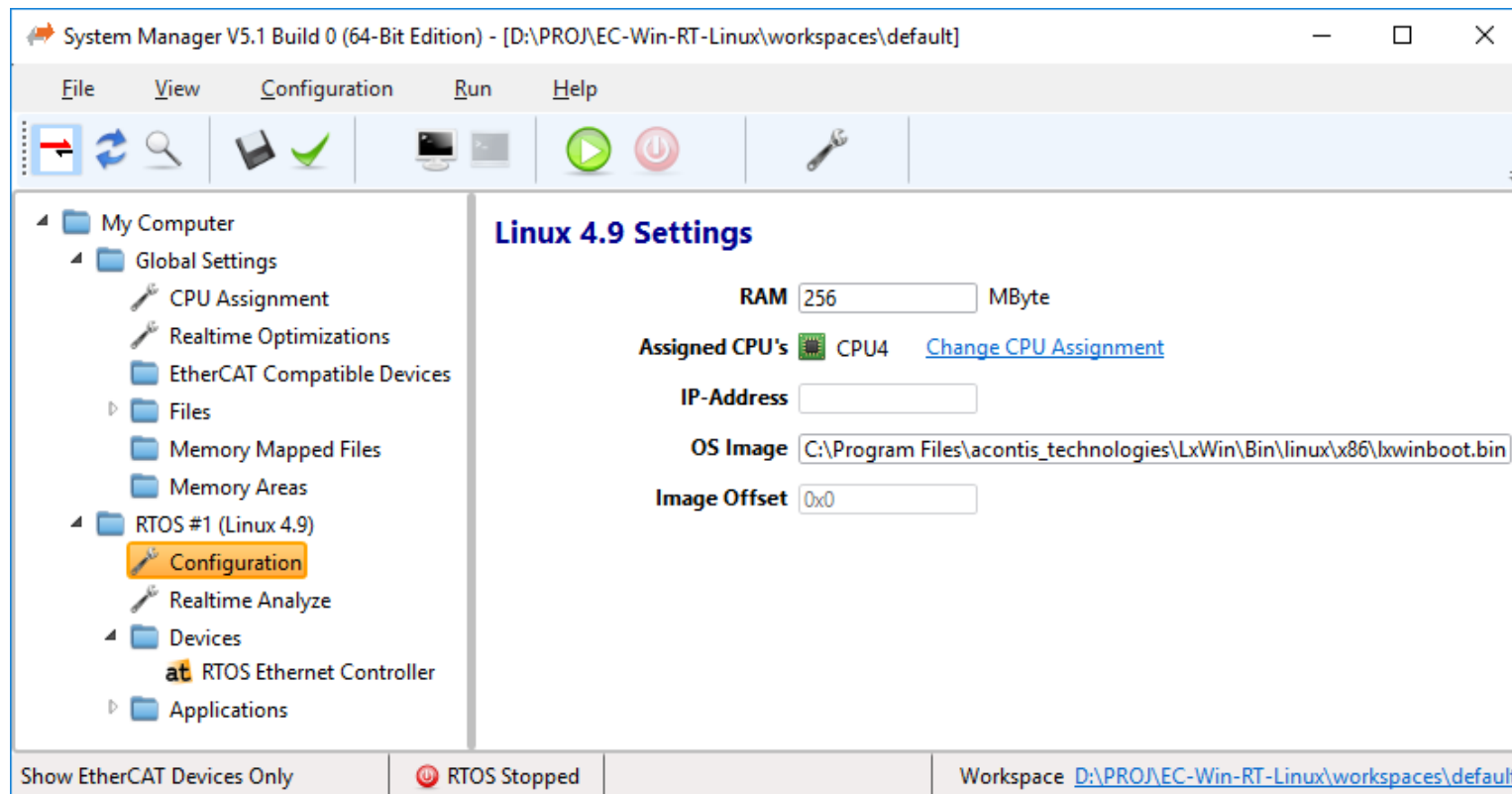
- Hardware Partitioning
- System Configuration (e.g. RAM size for Linux)
- Launch Panel (e.g. start/stop Linux)



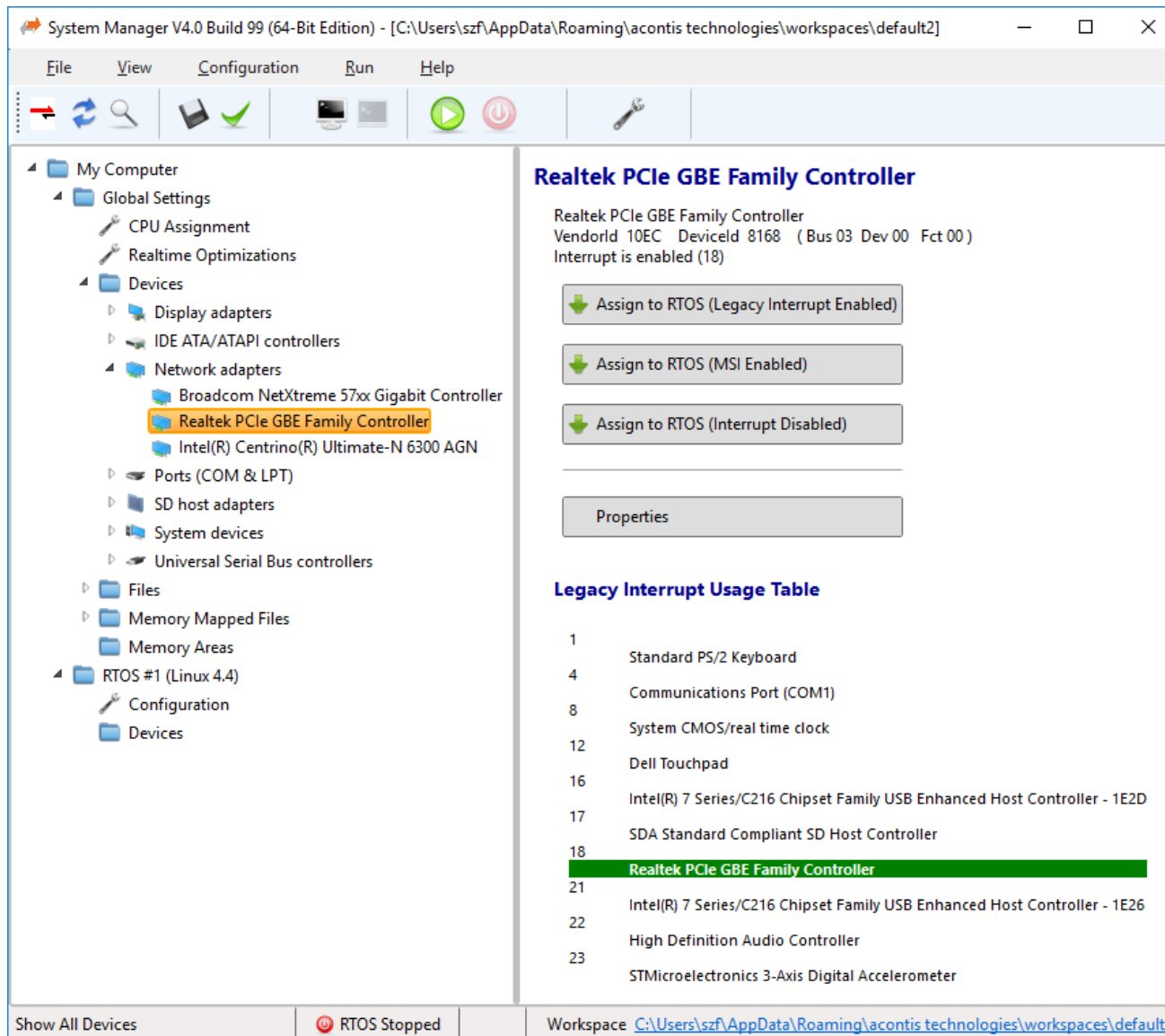
- CPU Assignment
 - Select number of CPUs to be used by Windows
 - Select CPU(s) to be used by Linux

- RAM Assignment

- Set RAM size for Linux, will be allocated at early boot stage, up to about 3 GByte
- Memory is invisible for Windows (and vice versa)!



System Manager Tool: Hardware Partitioning

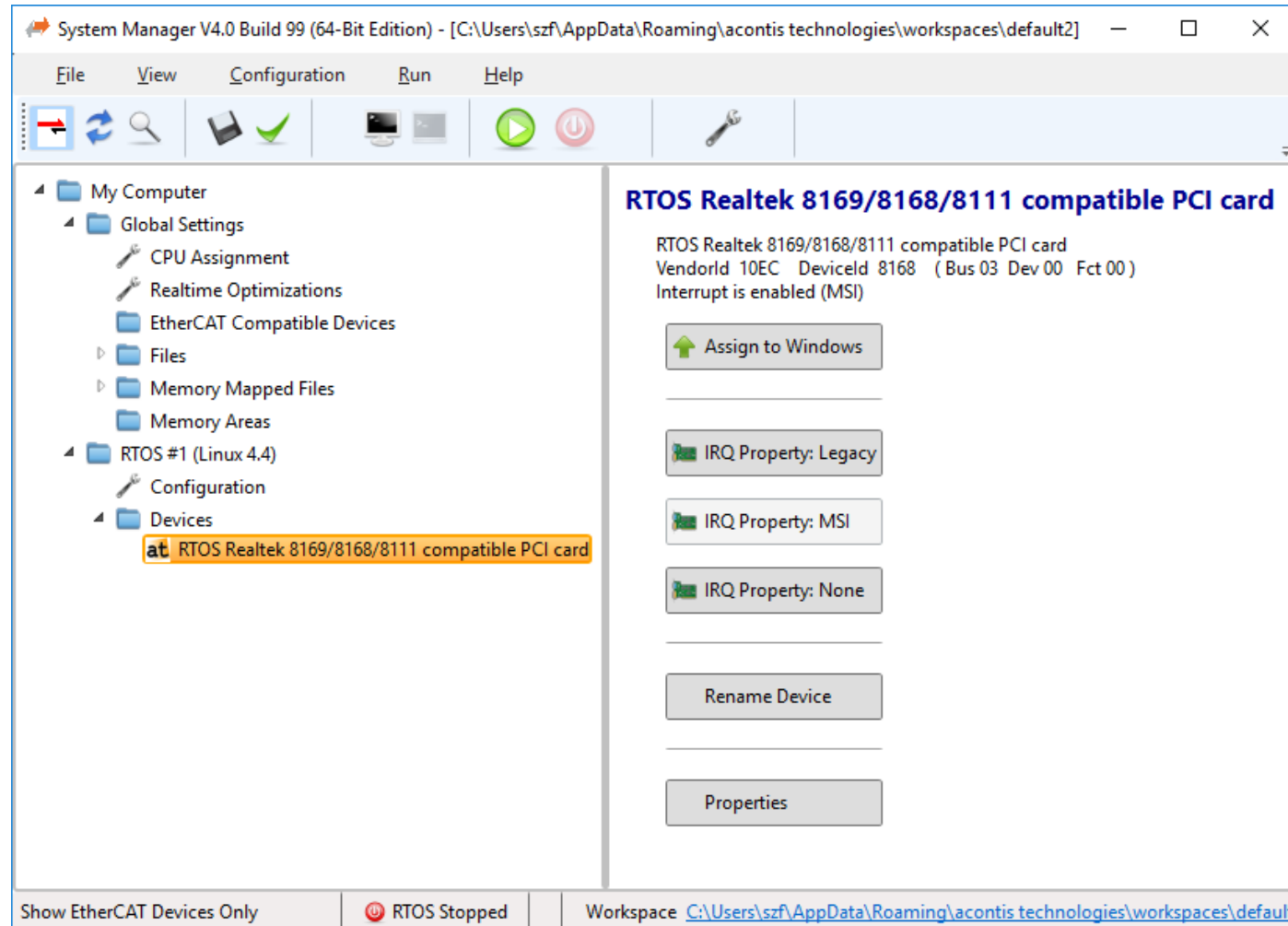


- Device Assignment

- Select Device currently controlled by Windows
- Assign Device to Linux

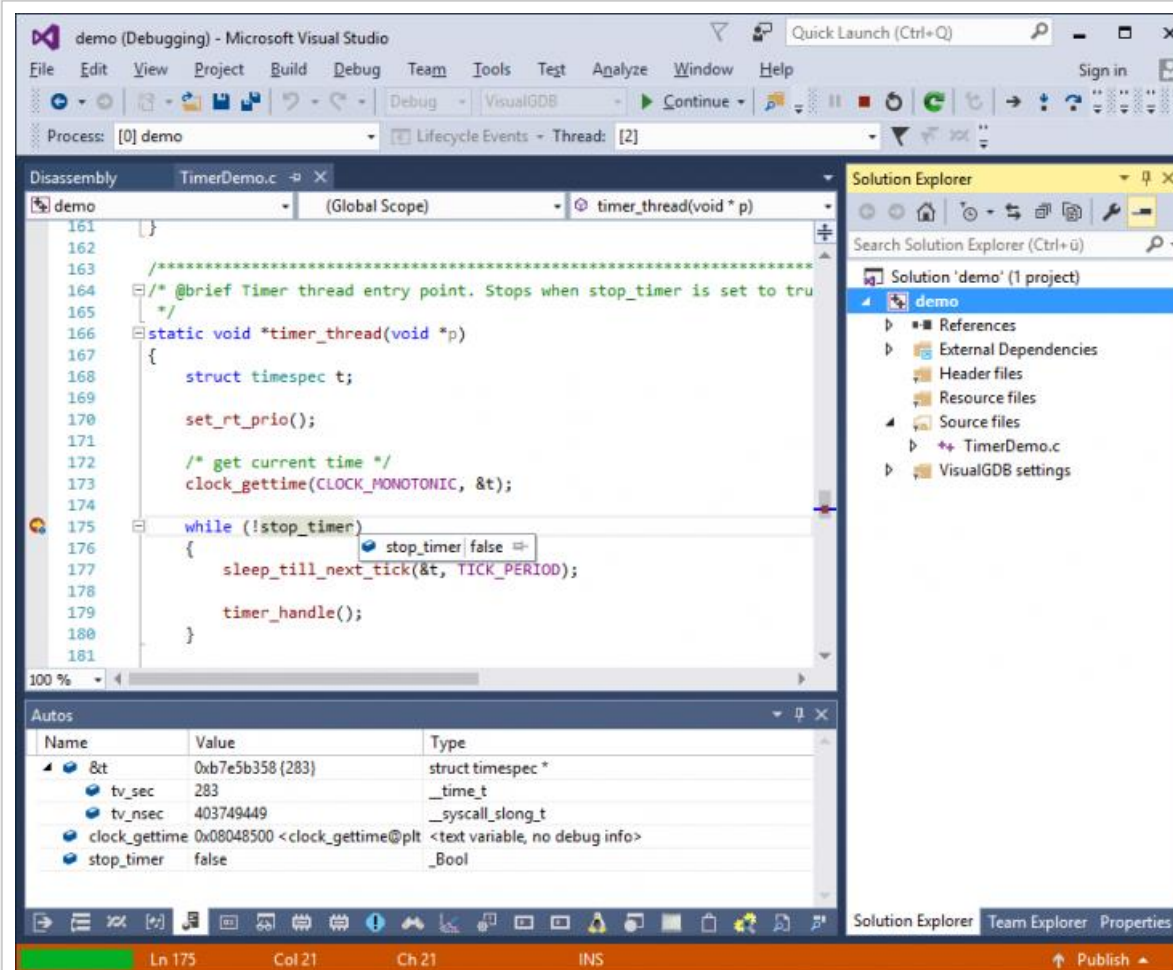
System Manager Tool: Hardware Partitioning

Device ready to use for Linux

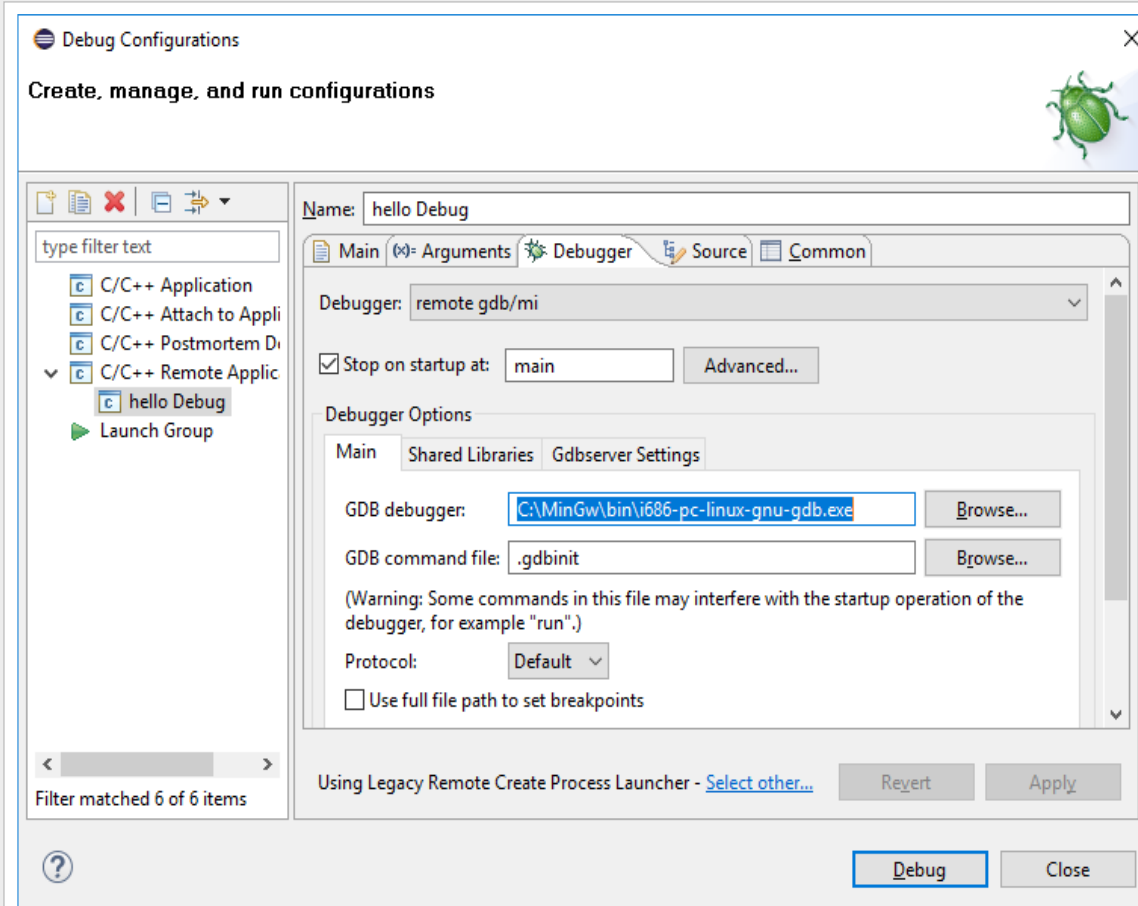




SOFTWARE Development



- Visual Studio
 - For Windows applications
 - For RT-Linux real-time applications
- Powerful VisualGDB plugin for real-time application development
- Project Wizards
 - Automatically Create new real-time applications
- Application Debugging
 - As convenient as debugging a regular Windows application



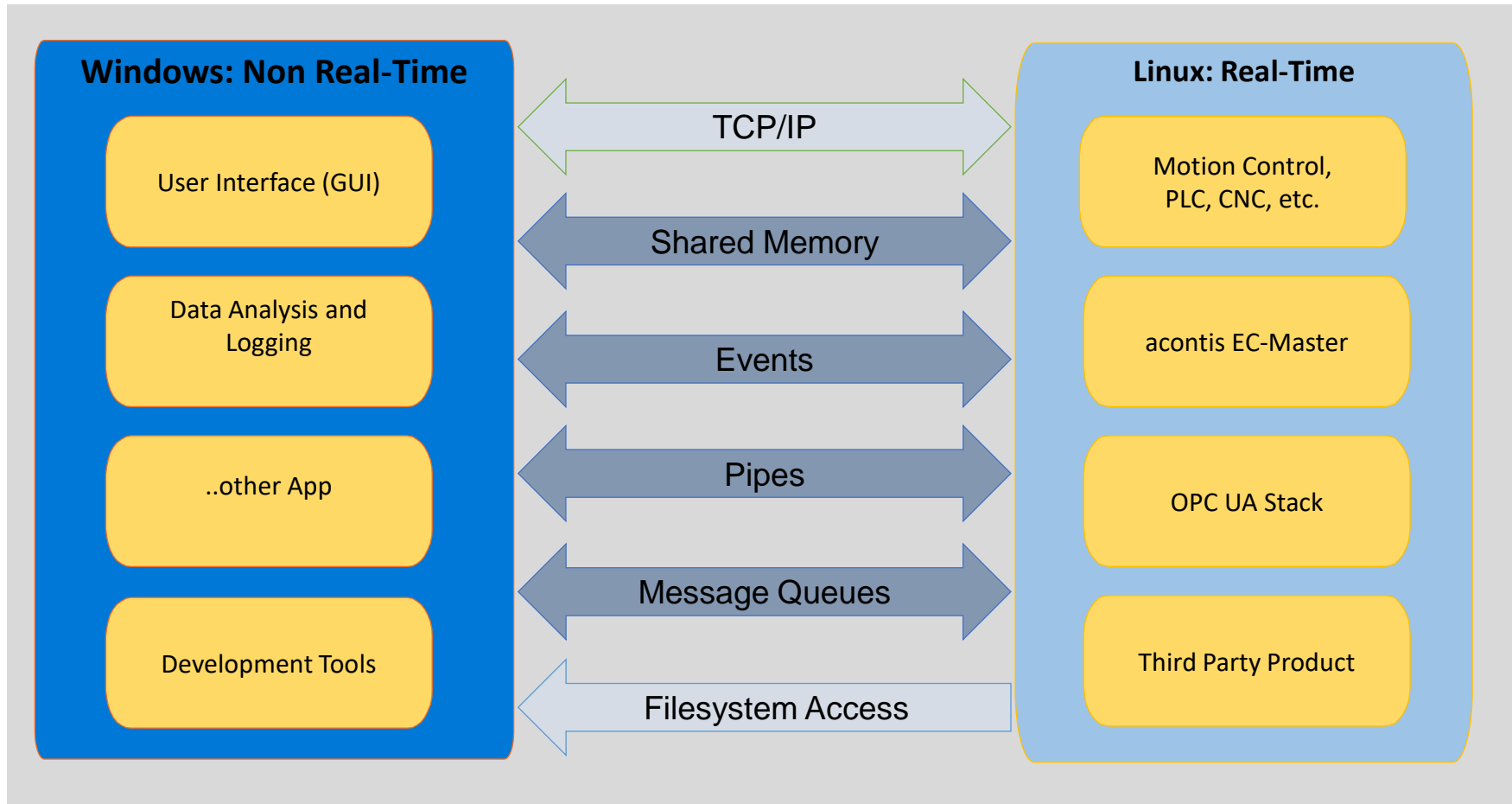
- Free and open source
- Standard IDE on Linux hosts
- Also available for Windows



Communication

Data and information exchange between Windows and Linux

Windows and Linux interaction



Virtual Console



- Can be used for Linux Shell

```
VIO0 - PuTTYtel
clocksource: Switched to clocksource tsc
CIFS VFS: Error connecting to socket. Aborting operation.
mount: mounting //192.168.157.1/BIN_LXWIN on /mnt/BIN_LXWIN failed: Operation
now in progress
Starting OpenBSD Secure Shell server: sshd
random: sshd: uninitialized urandom read (32 bytes read, 0 bits of entropy ava
ilable)

LxWin (acontis distro based on poky) 1.0 vmf /dev/console

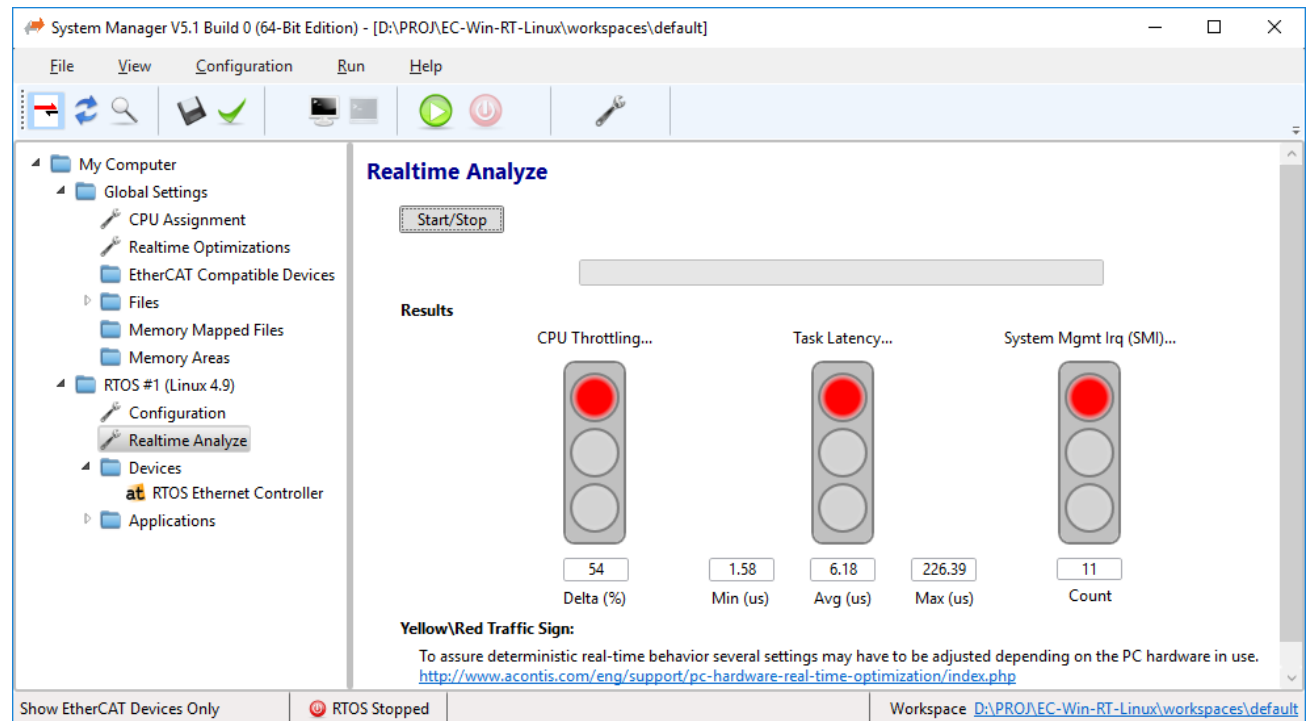
vmf login: root
Password:
root@vmf:~# ls -l /
total 12
drwxr-xr-x  2 root root 1800 Nov 14 13:51 bin
drwxr-xr-x  2 root root  40 Oct 25 13:39 boot
drwxr-xr-x  2 root root 100 Nov 14 13:51 conf
drwxr-xr-x  3 root root 2760 Nov 15 17:09 dev
drwxr-xr-x 20 root root  940 Nov 15 17:09 etc
drwxr-xr-x  3 root root  60 Nov 14 13:51 home
-rwxr-xr-x  1 root root 8356 Nov 14 13:50 init
drwxr-xr-x  4 root root 1180 Nov 14 13:51 lib
drwxr-xr-x  2 root root  40 Oct 25 13:39 media
drwxr-xr-x  3 root root  60 Nov 15 17:09 mnt
dr-xr-xr-x 76 root root   0 Nov 15 17:09 proc
drwx----- 2 root root  40 Nov 10 11:55 root
drwxr-xr-x  4 root root 120 Nov 15 17:10 run
drwxr-xr-x  2 root root 920 Nov 14 13:51/sbin
drwxr-xr-x  7 root root 200 Nov 14 13:51/scripts
dr-xr-xr-x 12 root root   0 Nov 15 17:09 sys
drwxrwxrwt  2 root root  40 Oct 25 13:39 tmp
drwxr-xr-x 11 root root 220 Oct 25 12:03 usr
drwxr-xr-x  8 root root 240 Nov 14 13:51 var
root@vmf:~#
```



Real-time on Windows

Real-time analysis and optimization

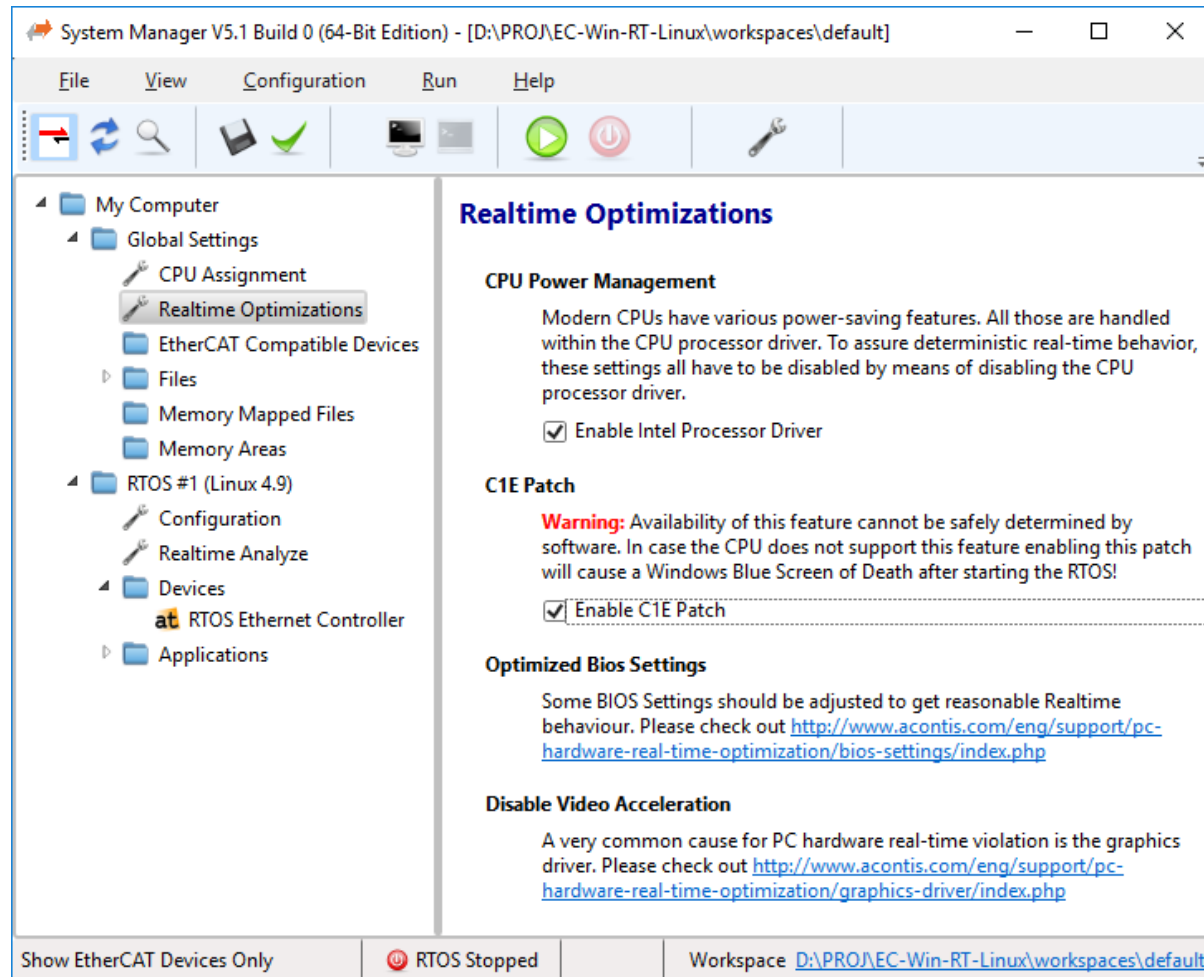
System Manager: Real-time analyzation (with optimization)



- Results
 - CPU clock: throttling active?
 - Timer: task level latency
 - System Management Interrupts?

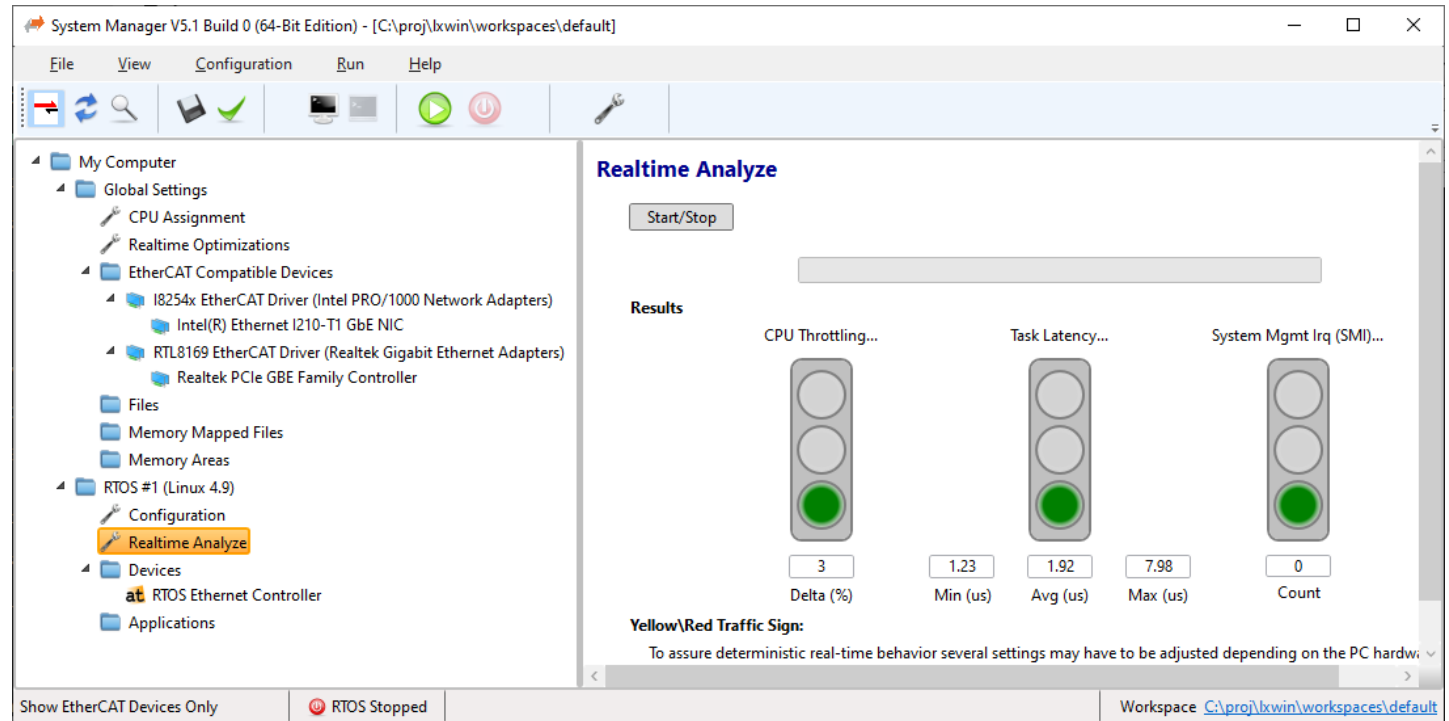
On non-optimized PCs real-time often cannot be guaranteed!

System Manager: PC real-time optimization



- Typical optimization steps
 - Disable CPU Power Management
 - Apply C1E Patch
 - BIOS settings (see hints on acontis website)
 - VGA Driver issue?

System Manager: Real-time analysis (with optimization)



- Results
 - CPU clock: no throttling
 - Timer: short task level latency
 - No SMIs

After applying one or multiple optimizations
→ most PCs will be able to run real-time applications!



Intel VT support

- Utilize more memory for Linux
 - Physical memory > 4GB can be used, even for 32 Bit Linux
 - Non-contiguous Windows Memory can be used
 - Example: 4 times 500 Mbyte Windows memory = 1 time 2 Gbyte Linux memory
- Support Shared Mode for Windows 64 Bit
 - Run Windows and Linux on the same physical core
- Better isolation: Fatal Linux kernel crash does not violate Windows
 - Exit into Virtual Monitor instead of system reboot
- Activate via configuration setting
 - Linux image and applications do not need to be changed



Quality Assurance

- Test lab to test products before a new version gets released
- More than 50 different PC's
 - some supplied by customers as reference systems
- A wide range of Intel and AMD processors
 - AMD: Athlon, Duron, Fusion etc.
 - Intel: Celeron/Pentium, Core i5/7, XEON, Atom etc.
- Different chipsets
 - Intel, Nvidia, VIA, SiS etc.
- Automated test scripts (e.g. ½ million start/stop cycles in one single test)

